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METHOD FOR FINISHING	)	
SURFACE OF SUCH TARGET	)	

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VERIFICATION OF TRANSLATION

Sir:

I, Isamu Ogoshi, having been warned that willful false statements and the like are punishable by fine or imprisonment or both, under section 1001 of Title 18 of the United States Code, and may jeopardize the validity of the above-captioned application and any patent issuing thereon, declare:

(1) I am a patent attorney authorized to practice law in Japan and am engaged in the practice of law with OGOSHI International Patent Office at Toranomom 9 Mori Bldg. 3F, 2-2, Atago 1-Chome, Minato-ku, Tokyo 105-0002, Japan.

(2) I am fluent in the Japanese and English Languages.

(3) I have reviewed the attached translation, and certify that it is an accurate English translation of the Japanese language international application of Shiro Tsukamoto filed on August 24, 2004 and given International Application No. PCT/JP2004/012083.

(4) All of the statements made herein of my own knowledge are true and all statements made herein on information and belief are believed to be true.

January 20, 2006  
Date

Isamu Ogoshi  
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SPUTTERING TARGET AND METHOD  
FOR FINISHING SURFACE OF SUCH TARGET

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TECHNICAL FIELD

The present invention relates to a hollow cathode sputtering target which generates few particles and which has superior surface cleansability, and to a surface finishing method of this target.

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BACKGROUND ART

In recent years, the sputtering method for forming a film from materials such as metal or ceramics has been used in numerous fields such as electronics, corrosion resistant materials and ornaments, catalysts, as well as in the manufacture of cutting/grinding materials and abrasion resistant materials.

Although the sputtering method itself is a well-known method in the foregoing fields, recently, particularly in the electronics field, a sputtering target suitable for forming films of complex shapes and forming circuits is in demand.

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Under these circumstances, a hollow cathode sputtering target has been proposed recently. This target is formed in the shape of a cup, and is referred to as a hollow cathode sputtering target based on such shape (e.g., refer to Patent Documents 1, 2, 3).

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With this hollow cathode sputtering target, high density plasma can be generated within the target, and, by further providing directivity in the sputtering direction, a via hole can be filled at a high aspect ratio without having to use a

conventional collimator.

As described above, a hollow cathode sputtering target has a function of a deposition method that is effective and easier to control in comparison to a conventional planar target.

5 Generally speaking, on the inside of a hollow cathode sputtering target, there are an erosion area to where a target is sputtered and a deposition area to where the sputtered atoms are deposited.

Ordinarily, a deposition area is formed at the bottom face, and there is a significant problem in that the redeposited film will easily peel in the vicinity of the  
10 deposition area, and contaminate the substrate by flying to or dropping on the substrate.

Generally, when using a planar target, the erosion face of the target is cleansed, the work-affected layer is removed and the surface roughness is reduced so as to suppress the generation of particles.

15 Meanwhile, when there is a target face or peripheral equipment that is not eroded, contrarily, a measure is adopted such as roughening the surface so as to capture the physical matter that comes flying from the target during sputtering (e.g., refer to Patent Document 4, 5, 6).

Patent Document 1: Japanese Patent Laid-Open Publication No. 2000-256843

20 Patent Document 2: Japanese Patent Laid-Open Publication No. 2001-98367

Patent Document 3: Publication No. 2002-531690 of Translation of International Application

Patent Document 4: Japanese Patent Laid-Open Publication No. H4-304367

Patent Document 5: Japanese Patent Laid-Open Publication No. H11-1766

25 Patent Document 6: Japanese Patent Laid-Open Publication No. H173965

Nevertheless, this kind of technology was applied in a hollow cathode

sputtering target to roughen the bottom face of the target so as to prevent the peeling of the deposited material (redeposited film), but was unsuccessful. Contrarily, at the stage of commencing the sputtering process, the result was such that the uniformity of deposition was unstable, and numerous particles were  
5 generated.

Therefore, there was no choice but to use a conventional hollow cathode sputtering target, and there are problems in that the evenness (uniformity) of the film is inferior, arcing and particles are generated, and the quality of the sputtered deposition will deteriorate.

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### DISCLOSURE OF THE INVENTION

Thus, an object of the present invention is to provide a hollow cathode sputtering target which has superior sputter film evenness (uniformity), generates  
15 few arcing and particles, is capable of suppressing the peeling of the redeposited film on the bottom face, and has superior deposition characteristics, as well as a method for stably manufacturing this target.

In order to achieve the foregoing object, the present inventors discovered that by improving/devising the inner bottom face of the hollow cathode sputtering target, a  
20 hollow cathode sputtering target which has superior sputter film evenness (uniformity), generates few arcing and particles, is capable of suppressing the peeling of the redeposited film on the bottom face, and has superior deposition characteristics, as well as a method for stably manufacturing this target, could be obtained.

25 Based on the foregoing discovery, the present invention provides:

1. A hollow cathode sputtering target comprising an inner bottom face having a

surface roughness of  $Ra \leq 1.0 \mu m$ , preferably  $Ra \leq 0.5 \mu m$ .

2. The hollow cathode sputtering target according to paragraph 1, comprising a bottom face having a surface roughness  $Ra$  equal to or less than a cylindrical inner peripheral face;

5 3. The hollow cathode sputtering target according to any one of paragraph 1 or paragraph 2 above, comprising a rough face at the outer peripheral edge;

4. The hollow cathode sputtering target according to paragraph 3 above, comprising a rough face formed by performing abrasive blasting to the outer peripheral edge;

10 5. The [hollow cathode] sputtering target according to any one of paragraphs 1 to 4 above, wherein the target is formed from a cladding material;

6. A surface finishing method of a hollow cathode sputtering target characterizing in polishing and etching the bottom face of the target so as to make the surface roughness of the inner bottom face  $Ra \leq 1.0 \mu m$ , preferably  $Ra \leq 0.5 \mu m$

15 The present invention yields a superior effect in that it is able to stably obtain a hollow cathode sputtering target which has superior film evenness (uniformity) from the initial stages of sputtering, generates few arcing and particles, is superior deposition characteristics, and favorable target usability.

Further, there is another significant effect of being able to considerably  
20 reduce the peeling of the redeposited from the inner bottom face of a hollow cathode target which was in particular a problem heretofore.

#### BRIEF DESCRIPTION OF THE DRAWINGS

25 FIG. 1 is a schematic diagram of the cross section and planar surface of the hollow cathode sputtering target showing the respective measurement points of the

surface roughness;

FIG. 2 is a diagram showing the uniformity upon sputtering a hollow cathode Ti target;

FIG. 3 is a diagram showing the generation of particles upon sputtering a hollow cathode Ti target;

FIG. 4 is a diagram showing the uniformity upon sputtering a hollow cathode Ta target; and

FIG. 5 is a diagram showing the generation of particles upon sputtering a hollow cathode Ta target;

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#### BEST MODE FOR CARRYING OUT THE INVENTION

The hollow cathode sputtering target of the present invention can be applied to ceramics of various metals, alloys, silicides and oxides, but there is no particular limitation to the material. In order to manufacture a hollow body (cup shape), processing methods such as forging, flattening, rolling, deep drawing or the like are employed. There is also no particular limitation to this manufacturing method.

Upon manufacture, what is particularly important is the surface finishing of the inside of the target. In other words, after forming the hollow cathode sputtering target, it is important to subject the bottom face of the target to lathe processing, polishing and etching so as to make the surface roughness of the bottom face  $Ra \leq 1.0 \mu m$ , preferably  $Ra \leq 0.5 \mu m$ .

With a sputtering target comprising an inner bottom face having a surface roughness of  $Ra \leq 1.0 \mu m$ , preferably  $Ra \leq 0.5 \mu m$ , in particular, it is desirable to comprise a bottom face having a surface roughness  $Ra$  equal to or less than the cylindrical inner peripheral face.

Meanwhile, it is also desirable that the erosion face also has a surface roughness of at least  $Ra \leq 1.0 \mu m$ , preferably  $Ra \leq 0.5 \mu m$ .

Further, the outer peripheral edge or outer peripheral face of the hollow cathode sputtering target is a non-erosion face, and it is desirable that such edge or  
5 face has a rough face. This will usually become a getter for capturing particles.

The hollow cathode sputtering target may be a single body, or the target may be formed from a cladding material. The inner bottom face of the hollow cathode sputtering target is required to have the same surface roughness as above; namely,  
10  $Ra \leq 1.0 \mu m$ , preferably  $Ra \leq 0.5 \mu m$ .

Although a curved face exists at the boundary of the bottom face and cylindrical inner face of the hollow cathode target, in the present invention, it is desirable that such curved portion is also polished such that the surface roughness of the surface thereof become  $Ra \leq 1.0 \mu m$ , preferably  $Ra \leq 0.5 \mu m$ .

## 15 Examples

The present invention is now explained in detail with reference to the Examples. Incidentally, these Examples are merely illustrative, and the present invention shall in no way be limited thereby. In other words, the present invention shall include the various modes and modifications contained in the technical spirit of  
20 this invention.

### (Example 1)

The inside face of a Ti hollow cathode target was finished by being subject to lathe processing, polishing (sandpapering) and etching. The outline of the obtained hollow cathode sputtering target is shown in FIG. 1. The measurement of the  
25 surface roughness of the target was conducted at the respective measurement points (1 to 6) shown in FIG. 1.



Table 1 shows the surface roughness Ra ( $\mu\text{m}$ ) of the inside of the target. As shown in Table 1, the surface roughness Ra of the bottom face corresponding to the measurement points 1 to 6 is  $0.5\mu\text{m}$  or less, and the surface roughness Ra of the cylindrical inner peripheral face was also  $0.5\mu\text{m}$  or less.

5 The results upon performing a sputtering test with this hollow cathode target are shown in FIG. 2 and FIG. 3. The uniformity showed favorable values from the initial stage, and there were roughly 900 particles on a single wafer. Further, peeling of the redeposited film of the inner bottom could not be observed up to the expected useful life.

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Table 1

	Example 1	Example 2	Comparative Example 1	Example 3	Example 4	Comparative Example 2
(1)	0.4	0.7	1.7	0.5	0.8	3.5
(2)	0.4	0.8	1.7	0.5	0.9	2.3
(3)	0.4	0.8	1.0	0.4	0.8	2.0
(4)	0.4	0.7	2.1	0.5	0.7	2.6
(5)	0.3	0.7	2.5	0.4	0.8	2.4
(6)	0.4	0.8	1.3	0.5	1.0	3.5

Ra( $\mu\text{m}$ )

(Example 2)

15 The inside face of a Ti hollow cathode target was finished by being subject to lathe processing, polishing (sandpapering) and etching so as to be Ra ( $\mu\text{m}$ ) < 1.0.

As with Example 1, the measurement of the surface roughness of the target was conducted at the respective measurement points (1 to 6) shown in FIG. 1. The

results are similarly shown in Table 1.

As shown in Table 1, the surface roughness  $R_a$  of the bottom face corresponding to the measurement points 1 to 6 is  $1.0\ \mu\text{m}$  or less, and the surface roughness  $R_a$  of the cylindrical inner peripheral face was also  $1.0\ \mu\text{m}$  or less.

5 The results upon performing a sputtering test with this hollow cathode target are shown in FIG. 2 and FIG. 3. As shown in FIG. 2, the uniformity showed favorable values from the initial stage. Also, as shown in FIG. 3, there were roughly 2,500 particles on a single wafer. Further, peeling of the redeposited film at the bottom of the inside face could not be observed up to the expected useful life.

#### 10 (Comparative Example 1)

The inside face of a Ti hollow cathode target was finished with only lathe processing. As with Example 1, the measurement of the surface roughness of the target was conducted at the respective measurement points (1 to 6) shown in FIG. 1.

15 Similarly, the surface roughness  $R_a$  ( $\mu\text{m}$ ) of the inside face of the target is shown in Table 1. As shown in Table 1, the surface roughness corresponding to the measurement points 1 to 6 was bottom face  $R_a = 1.3$  to  $2.5\ \mu\text{m}$ , and side face  $R_a = 1.0$  to  $1.7\ \mu\text{m}$ .

20 Results of the sputtering test are related to Examples 1 and 2, and the measurement results of uniformity and the number of particles are shown in FIG. 2 and FIG. 3.

As shown in FIG. 2 and FIG. 3, the uniformity is inferior from the initial stage, and the number of particles on a single wafer was larger in comparison to Examples 1 and 2 at 25,000 particles. Further, after the use of roughly 8000kWhr, peeling of the redeposited layer on the bottom of the inside face was confirmed.

#### 25 (Example 3)

The inside face of a Ta hollow cathode target was finished by being subject

to lathe processing, polishing (sandpapering) and etching. As with Example 1, the measurement of the surface roughness of the target was conducted at the respective measurement points (1 to 6) shown in FIG. 1.

The surface roughness  $R_a$  ( $\mu\text{m}$ ) of the inside face of the target is shown in Table 1. As shown in Table 1, the surface roughness  $R_a$  at the measurement points 1 to 6 was 0.4 to 0.5  $\mu\text{m}$ .

As a result of performing a sputtering test with this hollow cathode target, as shown in FIG. 4, the uniformity showed favorable values from the initial stage. Also, as shown in FIG. 5, there were roughly 500 particles on a single wafer. Further, peeling of the redeposited film at the bottom of the inside face could not be observed up to the expected useful life.

#### (Example 4)

The inside face of a Ta hollow cathode target was finished by being subject to lathe processing, polishing and etching. As with Example 1, the measurement of the surface roughness of the target was conducted at the respective measurement points (1 to 6) shown in FIG. 1.

The surface roughness  $R_a$  ( $\mu\text{m}$ ) of the inside face of the target is shown in Table 1. As shown in Table 1, the surface roughness  $R_a$  at the measurement points 1 to 6 was 0.7 to 1.0  $\mu\text{m}$ .

As a result of performing a sputtering test with this hollow cathode target, as shown in FIG. 4, the uniformity showed favorable values from the initial stage. Also, as shown in FIG. 5, there were roughly 1,800 particles on a single wafer. Further, peeling of the redeposited film at the bottom of the inside face could not be observed up to the expected useful life.

#### (Comparative Example 2)

The inside face of a Ta hollow cathode target was finished with only lathe

processing. As with Example 1, the measurement of the surface roughness of the target was conducted at the respective measurement points (1 to 6) shown in FIG. 1.

Similarly, the surface roughness  $R_a$  ( $\mu\text{m}$ ) of the inside face of the target is shown in Table 1. As shown in Table 1, the surface roughness corresponding to the measurement points 1 to 6 was bottom face  $R_a = 2.4$  to  $3.5 \mu\text{m}$ , and side face  $R_a = 2.0$  to  $3.5 \mu\text{m}$ .

Results of the sputtering test are related to Examples 3 and 4, and the measurement results of uniformity and the number of particles are shown in FIG. 4 and FIG. 5.

As shown in FIG. 4 and FIG. 5, the uniformity is inferior from the initial stage, and the number of particles on a single wafer was larger in comparison to Examples 3 and 4 at 6,000 particles. Further, peeling of the redeposited layer on the bottom of the inside face was confirmed after the expected useful life.

#### Industrial Applicability

The present invention is advantageous in that the function of a hollow cathode sputtering target can be further improved since a target which has superior sputter film evenness (uniformity), generates few arcing and particles, is capable of suppressing the peeling of the redeposited film on the bottom face, and has superior deposition characteristics can be manufactured.